Revision Notes for CBSE Class 10 Science Notes for Chapter 4 Carbon and its Compounds:

Covalent Bond: The bond formed by mutual sharing of electron pairs between two atoms in a molecule is known as Covalent Bond.

Covalent bonding in carbon compounds

The atomic number of carbon is 6 and its electronic configuration is 2, 4. Therefore, needs to gain or lose four electrons to attain noble gas configuration. But it is not possible for carbon to form ionic bonds due to the following reasons:

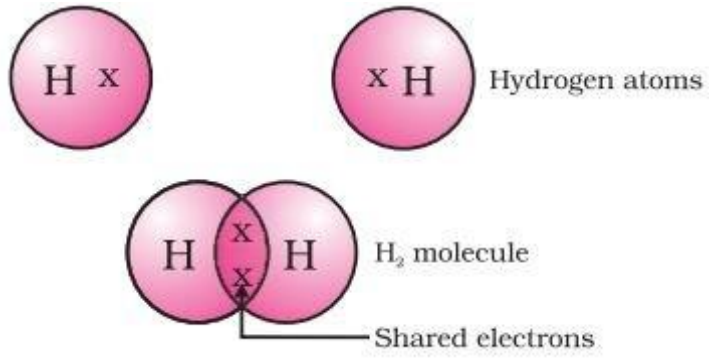
(i) It could gain four electrons forming C^{4-} cation. But it would be difficult for the nucleus with six protons to hold on to ten electrons.

(ii) It could lose four electrons forming C^{4+} cations. But it requires a large amount of energy to remove four electrons.

Carbon overcomes this problem by sharing its valence electrons with other carbon atoms or with atoms of other elements. Thus, carbon forms covalent bonds.

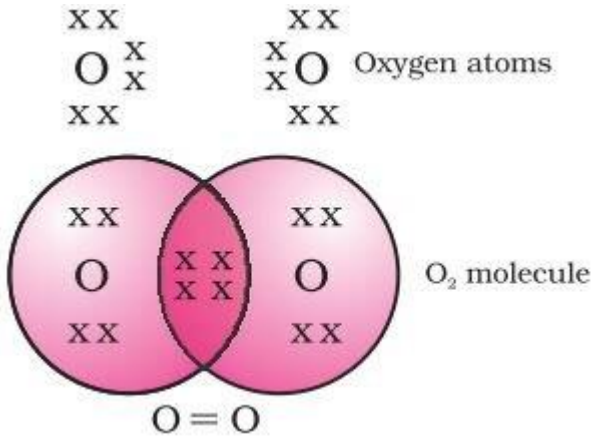
Formation of hydrogen molecule (Single Bond):

The atomic number of hydrogen is 1. Hence it has one electron in its K shell and it requires one more electron to fill the K shell. So two hydrogen atoms share their electrons to form a molecule of hydrogen, H_2.



Formation of oxygen molecule (Double Bond):

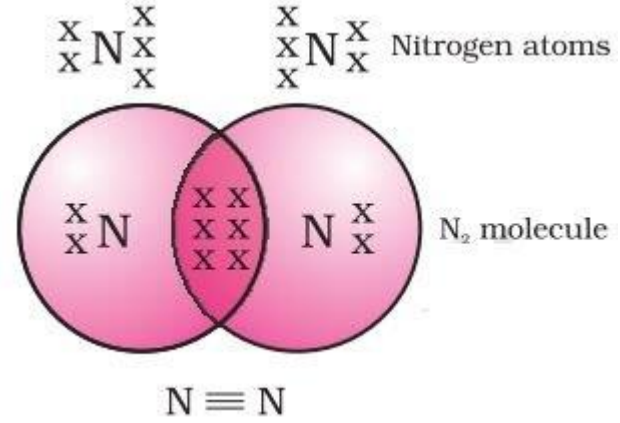
The atomic number of oxygen is 8. So it has six electrons in its L shell and it requires two more electrons to complete its octet. So each atom of oxygen shares two electrons with another atom of oxygen. The two electrons contributed by each oxygen atom give rise to a double bond between the two atoms.



O_2 molecule

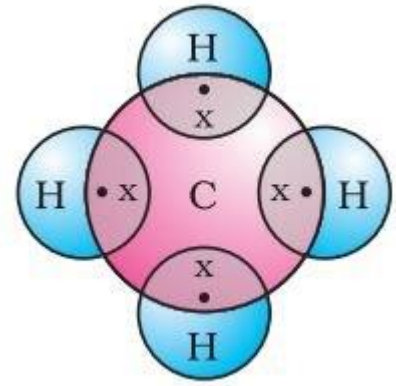
Formation of nitrogen molecule (Triple Bond)

Nitrogen has the atomic number 7. So it has five electrons in its L shell and it requires three more electrons to complete its octet. So, in order to attain an octet, each nitrogen atom in a molecule of nitrogen contributes three electrons giving rise to three shared pairs of electrons that results in a triple bond between the two atoms.



N_2 molecule

Formation of methane (CH_4)



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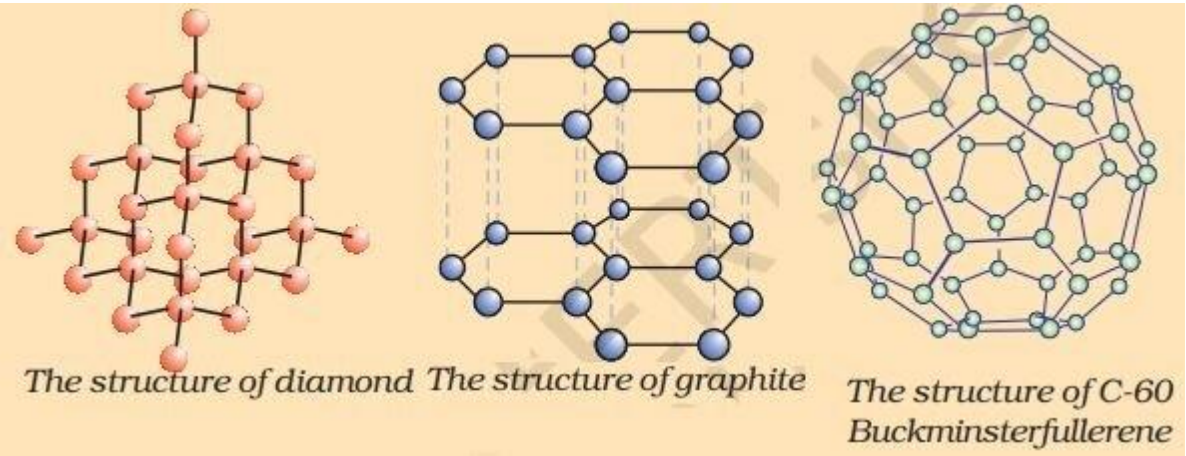
Allotropes of Carbon

Different forms of an element that have same chemical properties but different physical properties are known as Allotropes.

There are three allotropes of carbon - Diamond, graphite and Fullerene



(i) Diamond

In diamond, each carbon atom is bonded to four other carbon atoms forming a rigid three-dimensional structure.

→ It is the hardest substance known.

→ It has high melting point.

→ It is a bad conductor of electricity.

→ It is used in making jewellery. It is also used in cutting and drilling tools.

(ii) Graphite

→ Each carbon atom is bonded with other three carbon atoms in the same plane forming hexagonal rings.

→ These rings are stacked over each other through weak Van der Waals forces.

→ Graphite is also a very good conductor of electricity.

→ It is used as dry lubricant.

→ It is used in making pencil lead.

(iii) Fullerene

→ C_{60}, also known as Buckminsterfullerene, is the most common form of fullerenes.

→ It has carbon atoms arranged in the shape of a football.

→ It consists of 60 carbon atoms arranged in 12 pentagons and 20 hexagons,

Versatile nature of carbon

Carbon is included in ten formation of a variety of compounds. This is due to the following two reasons:

(i) Catenation: Carbon has the unique ability to form covalent bonds with other atoms of carbon, giving rise to large molecules. This property is called catenation.

Carbon exhibits catenation property due to the following reasons:

→ Size of the carbon atom is very small. This enables its nucleus to hold the shared pair of electrons strongly.

→ The carbon-carbon bond is quite strong.

(ii) Tetravalent Nature: Since carbon has a valency of four, it is capable of bonding with four other atoms of carbon or atoms of some other mono-valent element.

Hydrocarbons

Compounds of carbon and hydrogen are known as hydrocarbons.
For example - Methane (CH_4), Ethane (C_2H_6), etc.

Saturated hydrocarbons: These hydrocarbons have all carbon-carbon single bonds. These are known as alkanes.

General formula = C_nH_{2n+2}

where n = number of carbon atoms

Unsaturated hydrocarbons: These hydrocarbons have at least one carbon-carbon double or triple bond.

→ Hydrocarbons with carbon-carbon double bond are known as alkenes. General formula = C_nH_{2n}

→ Hydrocarbons with carbon-carbon triple bond are known as alkynes. General formula = C_nH_{2n-2}

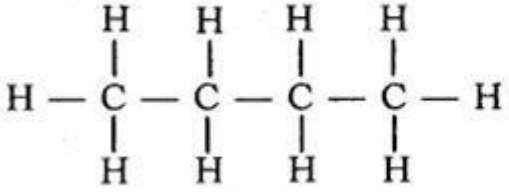
Structural Isomers

Isomers

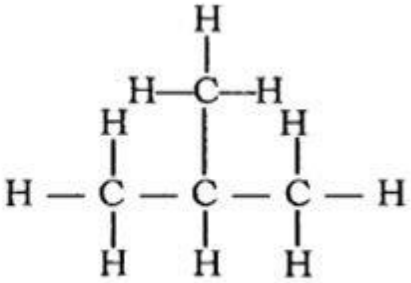
The compounds with the same molecular formula and different physical or chemical properties are known as isomers.

Compounds with identical molecular formula but different structures are called **structural isomers**.

Isomers of butane:

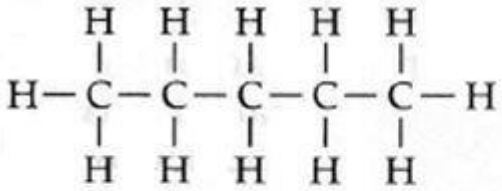


n - Butane

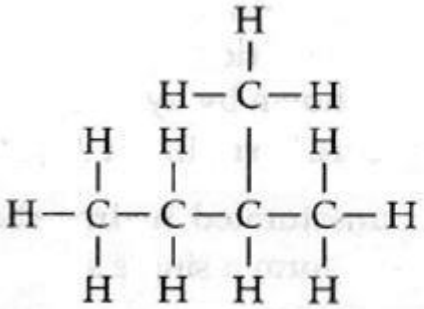


Iso-Butane

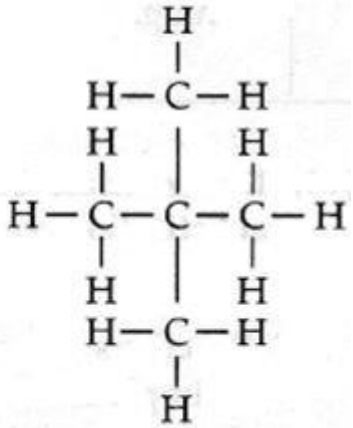
Isomers of pentane:



n – Pentane

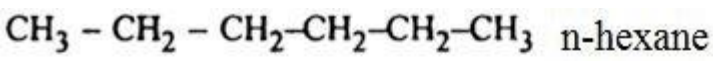


iso – Pentane

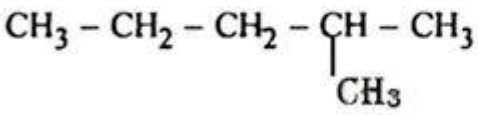


neopentane

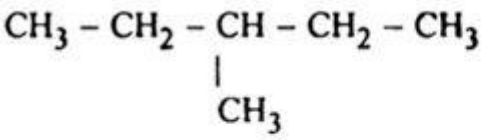
Isomers of hexane:



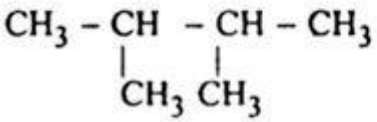
n-hexane



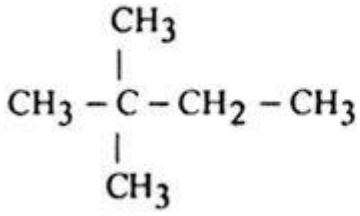
2-methyl pentane



3-methyl pentane



2, 3-dimethyl butane



2, 2-dimethyl butane

Homologous series

A series of organic compounds having the same functional group and chemical properties and in which the successive members differ by CH_2 unit or 14 mass units is known as Homologous series.

Characteristics of homologous series are:

Close Player

- The successive members in homologus series differ by CH_2 unit or 14 mass unit.
- All compounds of a homologous series have the same functional group.
- All compounds of homologous series shows similar chemical properties due to the addition of same kind of functional group throughout the chain.

For example,

Homologous series of alkanes is CH_4 (Methane), C_2H_6 (Ethane), C_3H_8 (Propane),....

Nomenclature of Carbon Compounds:

1. Identify the number of carbon atoms in the compound.

2. Functional group is indicated either by prefix or suffix.

Functional Group	Suffix
Alkene	ene
Alkyne	yne
Alcohol	ol
Aldehyde	al
Ketone	one
Carboxylic acid	oic acid

3. If a suffix is added, then final 'e' is removed from the name eg. methanol (methane - e = methan + ol).

Chemical properties of Carbon compounds :

1. Combustion

⇨ Carbon compounds generally burns (oxidize) in air to produce carbon dioxide and water, and release heat and light energy.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$ + heat and light

⇨ Saturated hydrocarbon burns generally with a blue flame in good supply or air and with a yellow sooty flame in limited supply of air.

⇨ Unsaturated hydrocarbons are burnt with a sooty flame.

⇨ Burning of coal and petroleum emits oxides of sulphur and nitrogen which are responsible for acid rain.

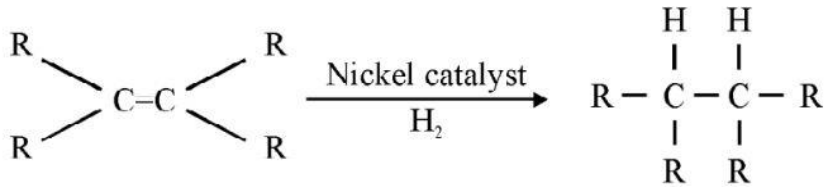
2. Oxidation

Alcohols can be converted to carboxylic acids by oxidizing them using alkaline potassium permanganate or acidified poatassium dichromate (they add oxygen to the reactant, thus are called oxidizing agents).

$$CH_3\text{-}CH_2OH \xrightarrow[\text{Acidified } K_2Cr_2O_7 + \text{heat}]{\text{Alkaline } KMnO_4 + \text{heat}} CH_3COOH$$

3. Addition Reaction

Hydrogen is added to unsaturated hydrocarbon in presence of palladium or nickel as catalyst. This process is used in converting vegetable oils into vegetable ghee.



Saturated fatty acids are harmful for health and oils with unsaturated fatty acids should be used for cooking.

4. Substitution Reaction

In saturated hydrocarbons, the hydrogen attached to carbon can be replaced by another atom or group of atoms in presence of sunlight.

$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (sunlight required)

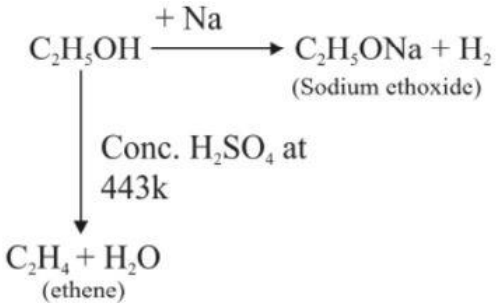
<u>Important Carbon Compounds</u>

Ethanol:

Chemical Properties of Ethanol

⇨ C_2H_5OH Reacts with Sodium to from Sodium Ethoxide and Hydrogen.

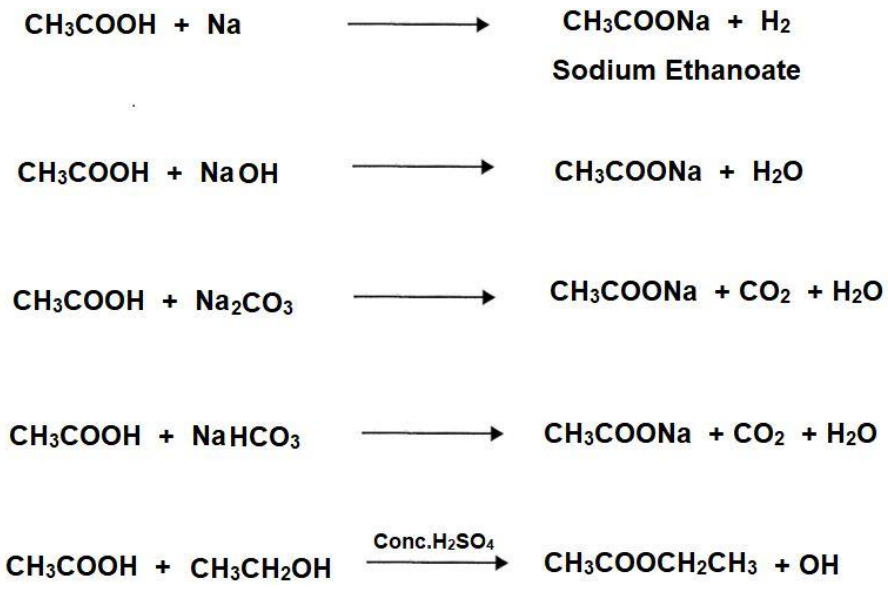
⇨ C_2H_5OH on heating with concentrated sulphuric acid at 443 K gets dehydrated to Ethene.



Uses of Ethanol

- In preparation of soap, cosmetics and medicines
- In alcoholic beverages
- As a laboratory reagent

Ethanoic Acid (CH_3COOH) or Acetic Acid:



⇨Pure acetic acid is called glacial acetic acid.

Esterification:

Carboxylic acids react with alcohols in presence of few drops of concentrated sulphuric acid as catalyst and form sweet smelling compounds called ester.

Hydrolysis:

Ester on heating with an acid or a base forms back the original alcohol and carboxylic acid.

Alkaline hydrolysis of ester is also called saponification.

Soaps and Detergents:

⇨ Soap is the sodium and potassium salt of carboxylic acids with long chain.

⇨Soaps are effective with soft water only. They do not form lather with hard water.

⇨ Detergents are ammonium or sulphonate salts of carboxylic acids with long chain. They are effective with both soft as well as hard water.

⇨ Soap is constituted of an ionic part which is hydrophilic and a long hydrocarbon chain which is hydrophobic.

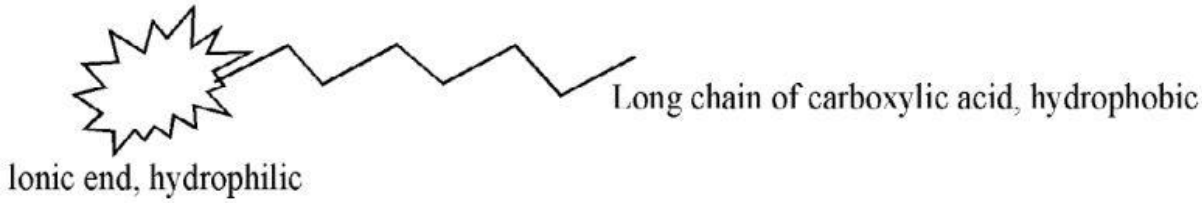
Structure of the soap molecule is as follows:

$$CH_3COO\ CH_2CH_3 + NaOH \longrightarrow CH_3COONa + CH_3\text{-}CH_2OH$$

$$CH_3COO\ CH_2CH_3 \xrightarrow[HEAT]{Dil.\ H_2SO_4} CH_3COOH + CH_3\text{-}CH_2OH$$

Cleansing Action of Soaps :

Most dirt is oily in nature and the hydrophobic end of the soap attaches itself with dirt, while the ionic end which is hydrophilic is surrounded with water molecules. This results in formation of a radial structure called micelles.



Soap molecule thus forms an emulsion. The cloth needs to be mechanically agitated to remove the dirt particles from the cloth.

Scum:

The magnesium and calcium salts present in hard water react with soap molecule to form insoluble products called scum that obstruct the cleansing action of soap.

Detergents are effective with hard water as the detergent molecule does not form insoluble compounds like scum.

Questions for self-assessment:

Q. Draw the electron dot structure of ethylene.

Q. How are covalent compounds different from ionic compounds?

Q. What are the two properties of carbon which lead to the huge number of carbon compounds we see around us?

Q. State any two characteristics of homologous series.

Q. Write first four members of homologous series of alkenes.

Q. Identify the functional group present in the following compounds: HCOOH, HCHO, CH_3Br and $C_{10}H_{21}OH$

Q. Write any three differences between soaps and detergents.

Important Questions

Multiple Choice Questions

1) C_3H_8 belongs to the homologous series of

(a) Alkynes
(b) Alkenes
(c) Alkanes
(d) Cyclo alkanes

2) Which of the following will undergo addition reactions?

(a) CH_4
(b) C_3H_8
(c) C_2H_6
(d) C_2H_4

3) In diamond, each carbon atom is bonded to four other carbon atoms to form

(a) a hexagonal array
(b) a rigid three-dimensional structure
(c) a structure in the shape of a football
(d) a structure of a ring

4) The allotrope of carbon which is a good conductor of heat and electricity is

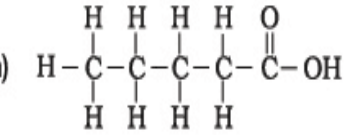
(a) diamond
(b) graphite
(c) charcoal
(d) none of these

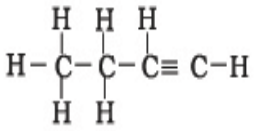
5) How many double bonds are there in a saturated hydrocarbon?

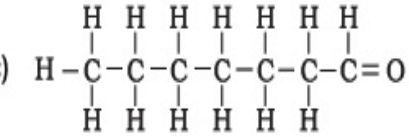
(a) One
(b) Two
(c) Three
(d) Zero

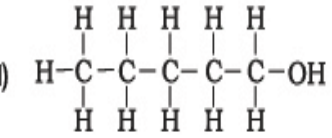
Short Answer Type Questions

1. Draw the electron dot structure of ethyne and also draw its structural formula
2. Write the names of the following compounds

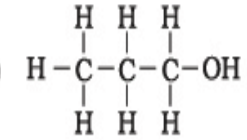
(a) 

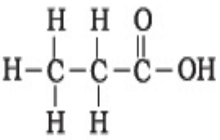
(b) 

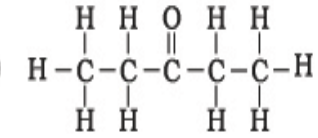
(c) 

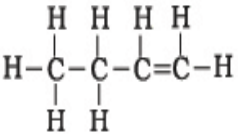
(d) 

3. Identify and name the functional groups present in the following compounds.

(a) 

(b) 

(c) 

(d) 

4. A compound X is formed by the reaction of a carboxylic acid $C_2H_4O_2$ and an alcohol in presence of a few drops of H_2SO_4. The alcohol on oxidation with alkaline $KMnO_4$ followed by acidification gives the same carboxylic acid as used in this reaction. Give the names and structures of (a) carboxylic acid, (b) alcohol and (c) the compound X. Also write the reaction.
5. Why detergents are better cleansing agents than soaps? Explain.
6. Name the functional groups present in the following compounds
   - (a) CH_3 CO CH_2 $CH_2CH_2CH_3$
   - (b) $CH_3CH_2CH_2COOH$

- (c) $CH_3CH_2CH_2CH_2CHO$
- (d) CH_3CH_2OH

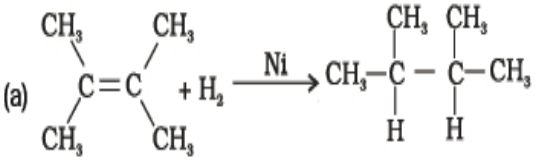
7. How is ethene prepared from ethanol? Give the reaction involved in it.
8. Intake of small quantity of methanol can be lethal. Comment.
9. A gas is evolved when ethanol reacts with sodium. Name the gas evolved and also write the balanced chemical equation of the reaction involved.
10. Ethene is formed when ethanol at 443 K is heated with excess of concentrated sulphuric acid. What is the role of sulphuric acid in this reaction? Write the balanced chemical equation of this reaction.
11. Carbon, Group (14) element in the Periodic Table, is known to form compounds with many elements.
    Write an example of a compound formed with
    - (a) chlorine (Group 17 of Periodic Table)
    - (b) oxgygen (Group 16 of Periodic Table)

12. In electron dot structure, the valence shell electrons are represented by crosses or dots.
    - (a) The atomic number of chlorine is 17. Write its electronic configuration
    - (b) Draw the electron dot structure of chlorine molecule.

13. Catenation is the ability of an atom to form bonds with other atoms of the same element. It is exhibited by both carbon and silicon. Compare the ability of catenation of the two elements. Give reasons.
14. Unsaturated hydrocarbons contain multiple bonds between the two C-atoms and show addition reactions. Give the test to distinguish ethane from ethene.
15. Match the reactions given in Column (A) with the names given in column (B).

Column (A)	Column (B)
(a) $CH_3OH + CH_3COOH \xrightarrow{H^+} CH_3COOCH_3 + H_2O$	(i) Addition reaction
(b) $CH_2 = CH_2 + H_2 \xrightarrow{Ni} CH_3 - CH_3$	(ii) Substitution reaction
(c) $CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$	(iii) Neutralisation reaction
(d) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$	(iv) Esterification reaction

16. Write the structural formulae of all the isomers of hexane.
17. What is the role of metal or reagents written on arrows in the given chemical reactions?

(a) 

(b) $CH_3COOH + CH_3CH_2OH \xrightarrow{\text{Conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$

(c) $CH_3CH_2OH \xrightarrow[\text{Heat}]{\text{Alk. } KMnO_4} CH_3COOH$

Long Answer Type Questions

1. A salt X is formed and a gas is evolved when ethanoic acid reacts with sodium hydrogencarbonate. Name the salt X and the gas evolved. Describe an activity and draw the diagram of the apparatus to prove that the evolved gas is the one which you ave named. Also, write chemical equation of the reaction involved.
2. (a) What are hydrocarbons? Give examples.
   (b) Give the structural differences between saturated and unsaturated hydrocarbons with two examples each.
   (c) What is a functional group? Give examples of four different functional groups.
3. Name the reaction which is commonly used in the conversion of vegetable oils to fats.

Explain the reaction involved in detail.

4. (a) Write the formula and draw electron dot structure of carbon tetrachloride.
   (b) What is saponification? Write the reaction involved in this process.
5. Esters are sweet-smelling substances and are used in making perfumes. Suggest some activity and the reaction involved for the preparation of an ester with well labeled diagram.
6. A compound C (molecular formula, $C_2H_4O_2$) reacts with Na – metal to form a compound R and evolves a gas which burns with a pop sound. Compound C on treatment with an alcohol A in presence of an acid forms a sweet smelling compound S (molecular formula, $C_3H_6O_2$). On addition of NaOH to C, it also gives R and water. S on treatment with NaOH solution gives back R and A. Identify C, R, A, S and write down the reactions involved.
7. Look at Figure 4.1 and answer the following questions

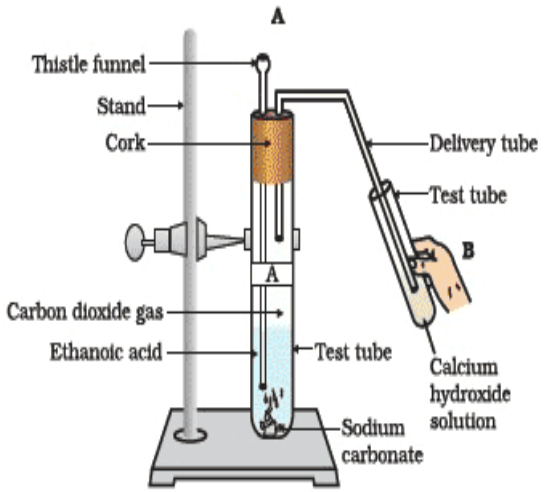


Fig. 4.1

- (a) What change would you observe in the calcium hydroxide solution taken in tube B?
- (b) Write the reaction involved in test tubes A and B respectively.
- (c) If ethanol is given instead of ethanoic acid, would you expect the same change?
- (d) How can a solution of lime water be prepared in the laboratory?

8. How would you bring about the following conversions? Name the process and write the reaction involved. Fig. 4.1
   - (a) ethanol to ethene.

- (b) propanol to propanoic acid.

Write the reactions.

9. Draw the possible isomers of the compound with molecular formula C_3H_6O and also give their electron dot structures.
10. Explain the given reactions with the examples
    - (a) Hydrogenation reaction
    - (b) Oxidation reaction
    - (c) Substitution reaction
    - (d) Saponification reaction
    - (e) Combustion reaction

11. An organic compound A on heating with concentrated H_2SO_4 forms a compound B which on addition of one mole of hydrogen in presence of Ni forms a compound C. One mole of compound C on combustion forms two moles of CO_3 and 3 moles of H_2O. Identify the compounds A, B and C and write the chemical equations of the reactions involved.